Mechanisms of Major Biliary Injury During Laparoscopic Cholecystectomy

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Laparoscopic cholecystectomy has become the procedure of choice for surgical removal of the gallbladder. The most significant complication of this new technique is injury to the bile duct. Twelve cases of bile duct injury during laparoscopic cholecystectomy were reviewed. Eight injuries were of a classic type: misidentification of the common duct for the cystic duct, resection of part of the common and hepatic ducts, and associated right hepatic arterial injury. Another injury was similar: clip ligation of the distal common duct with proximal ligation and division of the cystic duct, resulting in biliary obstruction and leakage. Three complications arose from excessive use of cautery or laser in the region of the common duct, resulting in biliary strictures. Evaluation of persistent diffuse abdominal pain led to the recognition of ductal injury in most patients. Ultimately, 10 patients required a Roux-en-Y hepaticojejunostomy to provide adequate biliary drainage. One patient had a successful direct common duct repair, and the remaining patient underwent endoscopic dilatation.

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ENTHUSIASM FOR LAPAROSCOPIC cholecystectomy has grown rapidly as recent reports have detailed the ease, efficacy, and safety of this procedure.[1-6] The Southern Surgeons Club reported an initial experience with 1518 cases collected during 1990,[7] and their experience has grown to over 9000 cases through early 1991. The overall complication rate reported in that series was small (5.1%) and included a number of very minor postoperative problems.

With the introduction of this new technique has come a learning period in which inexperience has resulted in a higher initial complication rate than will be expected later. The learning curve is highlighted in the Southern Surgeons Club experience by the incidence of bile duct injury. Within the first 13 cases of any participant's experience, the bile duct injury rate was 2.2%, compared with 0.1% after the 13th case.[7] The overall incidence of undetected common or hepatic duct injury was small (0.2%) in that series; however, those complications caused significant complications. This report documents and analyzes a series of 12 common or hepatic duct injuries that occurred during laparoscopic cholecystectomy and were subsequently referred to one medical center. This medical center had participated in the Southern Surgeons Club experience, but the injuries described here occurred outside of that experience. The videotapes of all but three original operations in which the injuries occurred were available, providing an opportunity to correlate intraoperative events with subsequent pathologic findings and to make suggestions for avoiding these complications.

Clinical Materials

The patients in this series were all referred to one surgeon at Duke University Medical Center for definitive care or advice in management of common or hepatic duct injuries sustained during laparoscopic cholecystectomy in the 11-month period from June 1990 through April 1991. The patients were referred by their primary physician within days of recognition of their injuries. As part of the management of these patients, operative videotapes were reviewed when available, in addition to the hospital records and roentgenograms. In each case, a precise mechanism seemed apparent, and subsequent operative findings, management, and clinical course correlated well with the presumed mechanism. The patients were seen regularly in follow-up after hospital discharge for 2 to 10

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months. Postoperative cholangiographic studies were performed only on the basis of clinical indications.

Results

Patient Profile

Twelve patients, seven women and five men, aged 22 to 76 years (mean, 45.4 years) were referred to Duke Medical Center. All but one patient had undergone laparoscopic cholecystectomy for chronically symptomatic gallstones demonstrated by ultrasound. The remaining patient had undergone laparoscopic cholecystectomy for acute cholecystitis confirmed radiographically by nonvisualizing oral cholecystogram (OCG) and endoscopic retrograde cholangiopancreatography (ERCP). Only one patient had another significant medical problem, that being severe coronary artery disease.

Original Procedure

The 12 patients in this series were referred by 11 general surgeons. Ten of these cases occurred within the first 11 laparoscopic procedures for these surgeons (1, 1, 3, 6, 7, 8, 9, 10, 11, and 11), whereas one case was the 91st of one surgeon's experience and another was the 100th. Nine surgeons performed the original procedure without other physicians assisting, and two were assisted by a second surgeon. Seven of the procedures were thought to have been "uncomplicated," whereas five were made difficult by significant inflammatory reaction around the gallbladder or portal area. Only three intraoperative cholangiograms were performed. Each was thought to have been normal; two patients subsequently developed common hepatic duct stricture, and the other was found to have partial ligation of the common duct. Five surgeons described significant intraoperative bleeding. One laparoscopic cholecystectomy was converted to an open laparotomy because of uncontrolled hemorrhage, and one patient was returned to the operating room for open exploration and right hepatic artery ligation after a significant hypotensive episode in the recovery room. In the remaining three cases, bleeding was adequately controlled laparoscopically.

Diagnosis of Biliary Injury

None of the ductal injuries reported in this survey were recognized at the time of the initial laparoscopic procedure. The diagnosis of a biliary injury was made 4 to 14 days after laparoscopic cholecystectomy in all but three of the patients; one was diagnosed on the first postoperative day, one was diagnosed 30 days after the initial procedure, and the other was diagnosed 6 weeks after the original procedure. In each case except one, evaluation of the patient's complaints of persistent diffuse pain eventually led to the discovery of bile duct injury. The remaining patient complained only of anorexia and fatigue 2 weeks after laparoscopic cholecystectomy. Laboratory studies disclosed an elevated total bilirubin in eight patients, with six being frankly jaundiced. The diagnosis of bile duct injury was established by ERCP in all but two patients. The diagnosis was made by percutaneous transhepatic cholangiography in one patient (Fig. 1A) after computerized tomography (CT) showed abnormal fluid collections, and by biliary scintigraphy in the other patient.

Initial Surgical Management

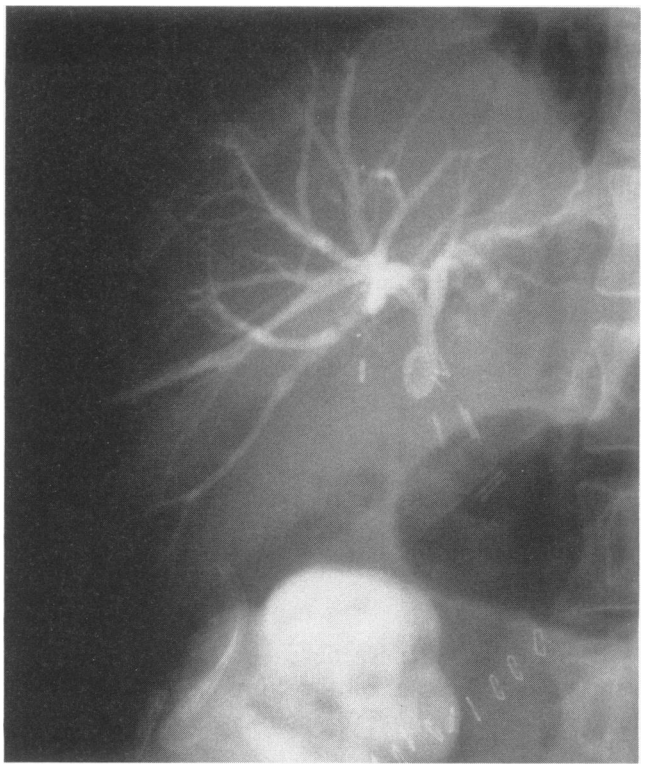
Four patients underwent surgical procedures subsequent to the diagnosis of biliary injury and before referral. Primary reanastomosis of transected bile ducts was attempted in two patients, but each failed because of anastomotic breakdown. A third patient simply had a tube placed into the proximal and distal ends of a divided ductal system for future identification of the anatomy, and the fourth simply had a subhepatic drainage catheter placed for collection of biliary ascites. The remaining patients were referred immediately to Duke on the recognition of biliary ductal injury.

Preoperative Management Following Transfer

Percutaneous transhepatic cholangiography or ERCP was performed at Duke after transfer in all cases to determine the precise site of injury. Cholangiography was followed immediately by CT scan to document or treat biliary leakage (four patients), as confirmed by demonstrating cholangiographic contrast material free in the peritoneal cavity (Fig. 2). One patient additionally had a perisplenic abscess drained by percutaneous techniques. All but one patient underwent preoperative placement of percutaneous transhepatic biliary catheters into the right and left hepatic ducts, both to determine the biliary anatomy and to assist in the identification of the proximal ductal system at laparotomy (Fig. 1B).

Description of Injuries

A definitive diagnosis was established by cholangiography in all cases. Eight patients had biliary obstruction due to partial (four) or complete (four) ligation of the biliary system (Fig. 3). Cholangiography demonstrated that four patients had completely decompressed ducts with subhepatic leakage of contrast and bile, but no ductal obstruction. The proximal borders of injury were as follows: common hepatic duct (five patients), confluence of the hepatic ducts (three patients), right hepatic duct (one patient), common duct (one patient), and several secondary hepatic biliary radicles (two patients). There were three strictures, two long and one short, with a continuous biliary system (Fig. 4). Each stricture was of the common



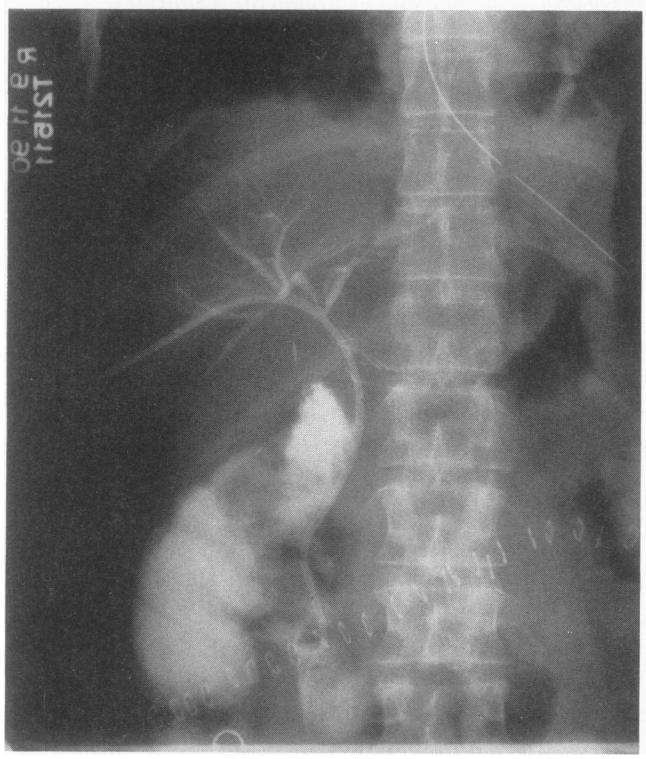


FIG. 1. (A, top left) Percutaneous transhepatic cholangiography showing complete common hepatic duct obstruction. (B, right) Preoperative percutaneous transhepatic catheter placed via the right hepatic ductal system into the obstructed common hepatic duct. (C, bottom left) Postoperative percutaneous cholangiogram showing patency of the hepaticojejunostomy without biliary leakage. The coronary O ring can be seen at the bottom of the radiograph.

hepatic duct system, with two extending into the common duct (*i.e.*, extending across the cystic duct junction). One patient had biliary leakage from an unligated cystic duct stump with complete common duct obstruction distally due to clip ligation (Fig. 5), suggesting that the distal "cystic duct" clips had been placed on the common duct. In each case without stricture in which cholangiography was performed, clips marked the distal ductal obstruction.

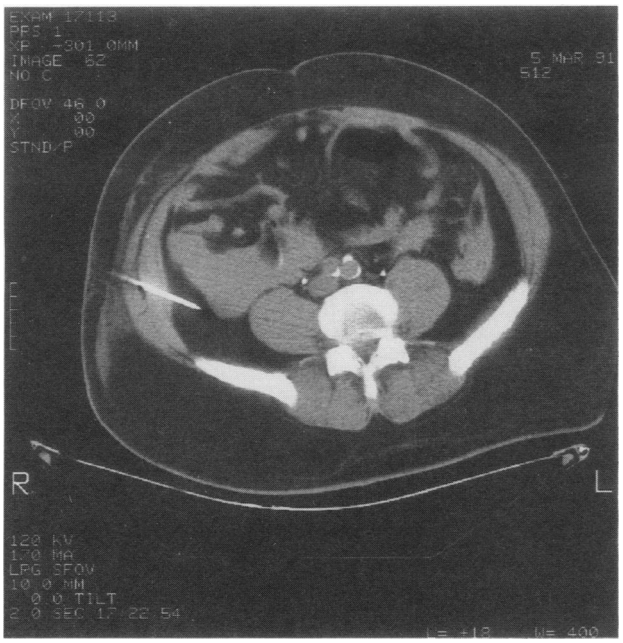


FIG. 2. Computed tomography–guided aspiration of intraperitoneal bile collection. This procedure was performed immediately after percutaneous transhepatic cholangiography. Note the presence of contrast material in the most dependent portion of this collection, confirming biliary leakage.

Review of Laparoscopic Videotapes

Each videotape was reviewed in its entirety after cholangiography and before surgery. In each case the injury was precisely identified, except in the three cases in which a stricture was presumed to have been secondary to repeated use of cautery or laser in the hilar area. In all but one of the other cases, inaccurate placement of the clips was seen with division of the bile duct and ligation or perforation of the right hepatic artery. Before division of the duct, in most cases, a small vascular branch to the common duct was clipped and divided as though it were the cystic artery (Fig. 3C).

Inadequate visualization of the operative field was obvious from the beginning of the film in four cases, indicating the surgeons' inexperience with laparoscopy. In no case was there camera or other equipment malfunction. In two cases the procedure was converted to open laparotomy because of significant bleeding. In one, brisk hemorrhage from the right hepatic artery obscured the scope and the procedure was immediately converted to an open one. In the other, the patient was initially observed in the recovery room but was returned to the operating room after a significant hypotensive episode. In

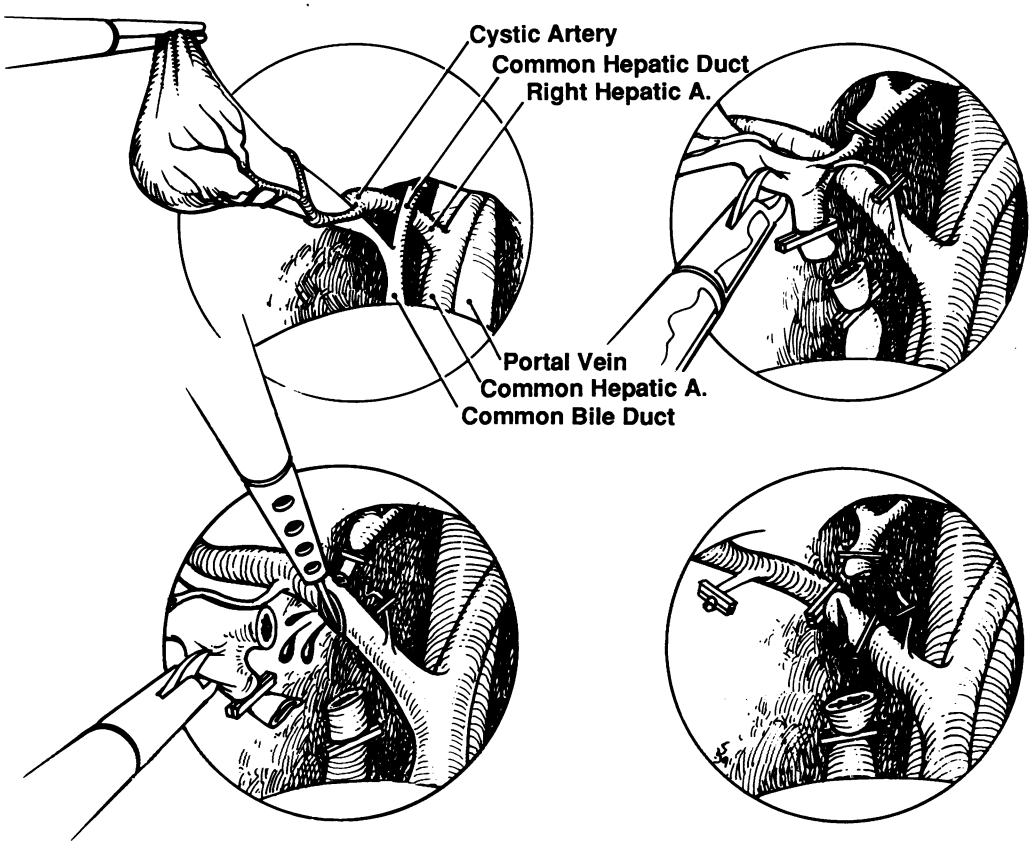
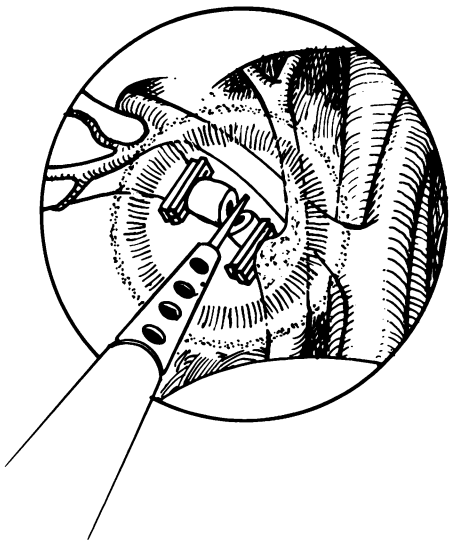


FIG. 3. The classic laparoscopic biliary injury. (A, top left) Normal portal anatomy. (B, top right) Misidentification of the common duct for the cystic duct, with subsequent ligation and division. (C, bottom left) Misidentification of the small arterial supply to the common duct for the cystic artery, with subsequent ligation and division. Note also injury of the right hepatic artery that invariably occurred during proximal division of the common hepatic duct. (D, bottom right) Ligation of the right hepatic artery and complete obstruction of the biliary system.



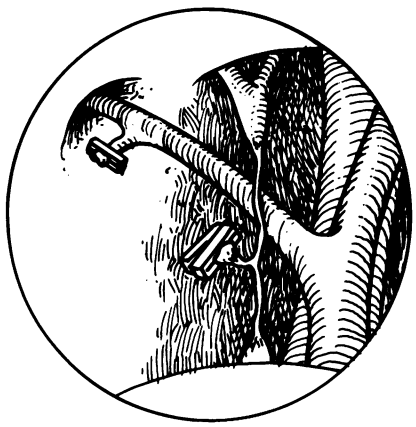


FIG. 4. Thermal injury to the portal triad, resulting in biliary stricture.

two cases obscured by significant scarring of the portal region, the grasping forceps were placed on the common duct rather than on the ampulla of the gallbladder during the dissection. The most common injury (Fig. 3) was dissection of the common hepatic and common bile ducts as though they were the cystic duct, division with or without clip ligation of the proximal hepatic ductal system, and then perforation or ligation of the right hepatic artery after initiation of cautery or laser dissection. In most cases significant bile leakage was present during much of the dissection. In all but two of the laceration injuries, there was excessive use of prograde rather than retrograde dissection of the presumed cystic duct, in other words, dissection primarily aimed toward the gallbladder rather than away from it.

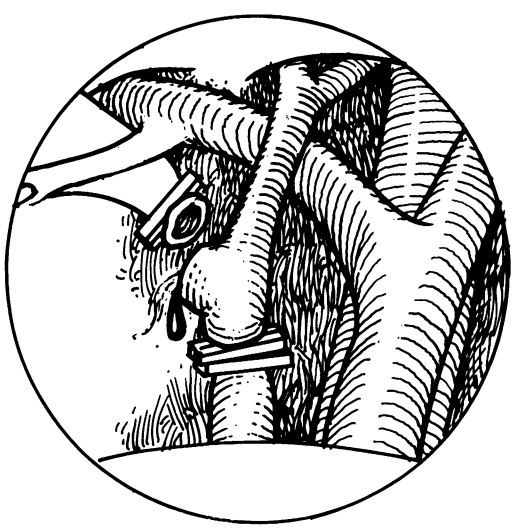


FIG. 5. Variant of the classic injury with placement of proximal clips on the cystic duct, but placement of the distal clips on the common duct. Division of the cystic duct between these two sites resulted in common duct obstruction, but biliary decompression through the free cystic duct stump.

Operative Management

One patient with a short common hepatic duct stricture and a continuous biliary system underwent biliary balloon dilatation with temporary stenting at ERCP and is awaiting further follow-up before a final decision about the need for surgery (Fig. 6). The patient with the anatomy depicted in Figure 4 simply had the common duct clip removed with oversewing of the cystic duct stump. The remaining patients underwent hepaticojejunostomy, with one of these anastomoses being made to the right hepatic duct only rather than to the common hepatic duct. The findings at the time of laparotomy supported the preoperative assessment in each case. Average operative time was 96 ± 5 minutes, and the average estimated blood loss was 184 ± 25 mL. A coronary "O" ring was placed routinely on the Roux segment and attached to the anterior abdominal wall to permit future percutaneous access to the anastomosis and biliary system, if necessary (Fig. 1C).

No complications occurred in the immediate postoperative period. Patients who had an elevation in serum bilirubin preoperatively had a decline to normal within 6 days after definitive surgery; the alkaline phosphatase was still abnormal, although decreasing at the time of hospital discharge in six of seven patients. The average length of hospitalization after hepaticojejunostomy was 9 days (range, 6 to 13 days). One of the patients developed cholangitis 4 months after hepaticojejunostomy and was found by CT scan to have mildly dilated intrahepatic biliary ducts. Retrograde percutaneous cholangiogram demonstrated debris at the anastomotic site, which was

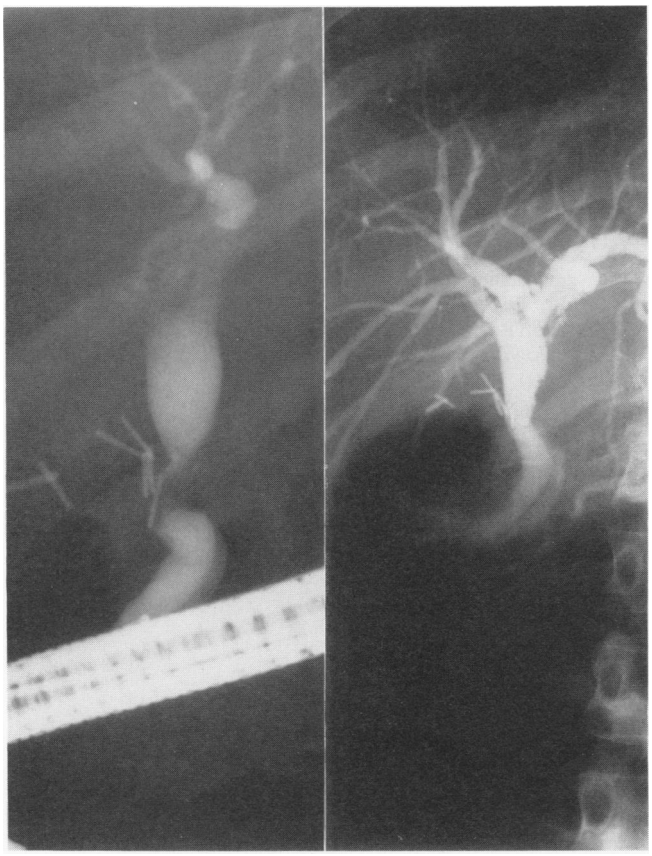


FIG. 6. Endoscopic retrograde cholangiograms showing (A, left) a common hepatic duct stricture and (B, right) the common hepatic duct after balloon dilatation.

removed by balloon catheter. A stent was placed across the anastomosis and removed after 3 weeks.

Discussion

Injury to the major biliary system after laparoscopic cholecystectomy caused two principle clinical manifestations: bile leakage into the abdomen with resultant pain and secondary bile peritonitis, and 2) biliary obstruction due to partial or complete hepatic or common duct ligation or late onset stricture.

Although it would clearly be better to recognize biliary injury at the time of laparoscopic cholecystectomy, the injury is likely to be unrecognized initially. Uncontrolled hemorrhage at the time of surgery should raise the suspicion of biliary injury and, if unusual measures are necessary to control the hemorrhage, particularly when there is inadequate visualization, burn or ischemic stricture of the common hepatic duct is possible. As with traditional, open procedures, technical aspects of the performance of the surgery appear to be important. Adequate visualization of the portal structures is essential. The cystic duct and artery should be identified clearly before ligation and division of any structures in the porta hepatis. Ideally, both the gallbladder–cystic duct and cystic duct–common duct junctions should be visualized and the surgeon should have a low threshold for cholangiography, particularly early in his experience, to help define the portal anatomy. Acute inflammation and chronic scarring of the gallbladder bed can restrict adequate identification of the anatomy, and early consideration of conversion to open cholecystectomy is important when the anatomy remains uncertain. During the hilar dissection, the cutting of a second distinct site along the duct should suggest the classic injury (Fig. 3). Finally, dissection away from the gallbladder neck toward the common duct, instead of the other direction, may help prevent the common duct from being mistaken for the cystic duct and subsequently being divided.

The classic pattern of laparoscopic injury appears to be misidentification of the common duct for the cystic duct, resection of a portion of the common and hepatic ducts, and an associated right hepatic arterial injury. A similar injury is known to occur with open cholecystectomy,[8] but not with the frequency or extent of hepatic duct resection. In addition, the operative videotapes with laparoscopic cholecystectomy provide an opportunity to determine definitively the mechanism of injury.

Although no single sign or symptom in the postoperative period was pathognomonic for ductal injury in this review, persistent patient complaints of diffuse abdominal pain should alert the physician to the possibility of a complication. One advantage of laparoscopic cholecystectomy should be that patients are relatively pain free after the procedure and, although there is much variability, complaints of severe or persistent pain should be carefully monitored and investigated early. Determination of serum alkaline phosphatase and total bilirubin are not particularly sensitive early in the initial postoperative course.

Three patients developed common hepatic duct strictures after laparoscopic cholecystectomy. Two presented 4 to 6 weeks after the initial procedure with jaundice and a completely obstructed duct, and the other returned 10 days after operation with diffuse abdominal pain and nausea, a slightly elevated serum alkaline phosphatase but normal total bilirubin, and was found to have a tight distal common duct stricture. The exact mechanisms for these injuries is not known for certain, but these strictures were probably caused by thermal injury or excessive manipulation of the common duct during the laparoscopic procedure. Smaller ducts may be particularly susceptible to stricture formation by these mechanisms. Therefore, judicious use of the laser or cautery during dissection in the portal region and minimizing the handling of the common duct cannot be overemphasized.

The principles of management of injuries sustained during laparoscopic cholecystectomy are essentially the same as for those sustained during open procedures. These include: early recognition of the injury, primary repair at the time of the initial laparoscopic procedure if possible, identification of the biliary anatomy before secondary operative repair, and Roux-en-Y hepaticojejunostomy unless there is a compelling reason not to do this. We have found preoperative percutaneous catheters to be particularly helpful at surgery for identification of the injured ducts and subsequent stenting if necessary, as well as preoperative CT drainage of intraperitoneal bile. Finally, intraoperative placement of a Roux-en-Y coronary "O" ring tacked to the anterior abdominal wall has been helpful in accessing the biliary system during postoperative follow-up. Most patients should have a successful result from hepaticojejunostomy unless there is technical difficulty, undiagnosed burn injury, or a divided duct is not incorporated into the hepaticojejunostomy.

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